

# EQUIPMENT

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## PHOSPHATE CARBURIZING OF GLASS MOLDS AND GLASS-SHAPING MACHINES

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The possibility of using phosphate carburization for hardening working surfaces of molds and parts of glass-shaping machines is demonstrated. Data on hardening of molds made of Sch 21-40 iron for different temperature and time parameters of the passivation process are given.

It is known that the output of acceptable product and the labor efficiency in the production of glass articles depends on the service life of the molding equipment and parts of the glass-shaping machines. They operate in stringent temperature conditions combined with the effect of chemically aggressive melted glass on the mold surface. The present paper is dedicated to the problem of the durability of molds and glass-molding machines.

Machine-producing enterprises used to harden molds and machine parts using different methods of chemical-thermal treatment, such as nitration and chrome-plating [1, 2]; however due to the fragility of the surface layer, this method did not become widely used in industry.

We have developed a combined method of passivation and hardening (phosphate carburizing) of glass molds and glass-shaping machine parts, which can be used both at machine-building and glass factories [3].

Major contributions to this work were made by scientists at the Institute of General and Inorganic Chemistry of the Academy of Sciences of the USSR, who developed the AKhFS and MIKS compositions, and by experimental research by the authors of [3–5]. Compounds AKhFS and MIKS are industrially produced in Russia according to TU 6-18-186–83. Their price is not too high, and their concentration in the passivating liquid solution is insignificant: 2–5 wt.%. The use of these compounds in a passivating liquid solution is determined by the fact that the diffusion layer emerging under heat treatment has enhanced heat-resistant parameters (1900°C) and chemical inertness to the glass melt. At the same time, the specified layer has antifrictional properties, similar to graphite. As opposed to the latter, this layer is not combustible. Furthermore, it has anticorrosive properties, which eliminates the application of lubricants in

storage and does not require manual maintenance. The hardening of the surface layer and parts improves their strength parameters and reduces the surface roughness.

The hardness and, consequently, the wear resistance of parts is achieved in phosphate carburization due to the formation of chemical compounds based on metal phosphides, in particular, ferric phosphide  $\text{Fe}_3\text{P}$ , on the surface of the machine part. The increased hardness of the gray iron surface is accounted for by the formation of a relatively low-melting triple eutectic which melts at 950°C and consists of phosphorus-enriched austenite, cementite, and ferric phosphide. These areas of phosphide eutectic increase the hardness and wear-resistance of the cast iron [6]. The latter fact was experimentally verified in the operation of glass molds made of cast iron Sch 21-40 and steel 40Kh13T.

Below are given the results of mold hardening in a 5% passivating solution ( $\text{pH} = 5$ ) at 60–65°C with varying exposure duration and subsequent heat treatment at 600–620°C for 30 min.

Duration of mold exposure in passivating solution, min	Brinell hardness
Without passivating treatment . . . . .	170
10 . . . . .	185–200
20 . . . . .	240–290
30 . . . . .	320–385
60 . . . . .	550–615

The modifications in the surface hardness of the molds made of Sch 21-40 cast iron resulting from passivation at various temperatures are listed in Table 1. The heat treatment duration in all cases was 40 min.

TABLE 1

Passivation duration, min	Heat treatment temperature, °C	Rockwell hardness
20	600	40 – 51
	850	63 – 65
	1000	51 – 52
40	600	41 – 43
	850	60 – 61
	1000	55 – 62
60	600	52
	850	61 – 62
	1000	54 – 56

As can be seen, the mold surface hardness increases with increasing heat treatment temperature, which depends on the passivation duration. The optimum conditions (Rockwell hardness 61 – 62) are reached at the heat treatment temperature of 850°C and heat treatment duration of 60 min. Therefore, in phosphate carburizing of Sch 21-40 iron molds, the surface hardness increases 5 – 6 times compared to the initial value (Brinell hardness 170 – 241), which cannot be accomplished by using other methods of chemical-thermal treatment.

The combined treatment of glass molds and glass-molding machine parts can be performed on domestic equipment produced industrially or made at the glass factory. We consider it expedient to combine both processes on the same production flow line [3]. The flow line for hardening of

molds and glass-shaping machine parts makes it possible, on the one hand, to mechanize and automate the treatment process and, on the other hand, to prevent the contamination of industrial waste sewage by the passivating reactants. On the flow line, the water used for washing is returned to the passivating liquid tank, which reduces the consumption of the aluminochromium phosphate binder.

This method for phosphate carburization of metals and alloys is currently implemented at several enterprises in Moscow and other regions.

## REFERENCES

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